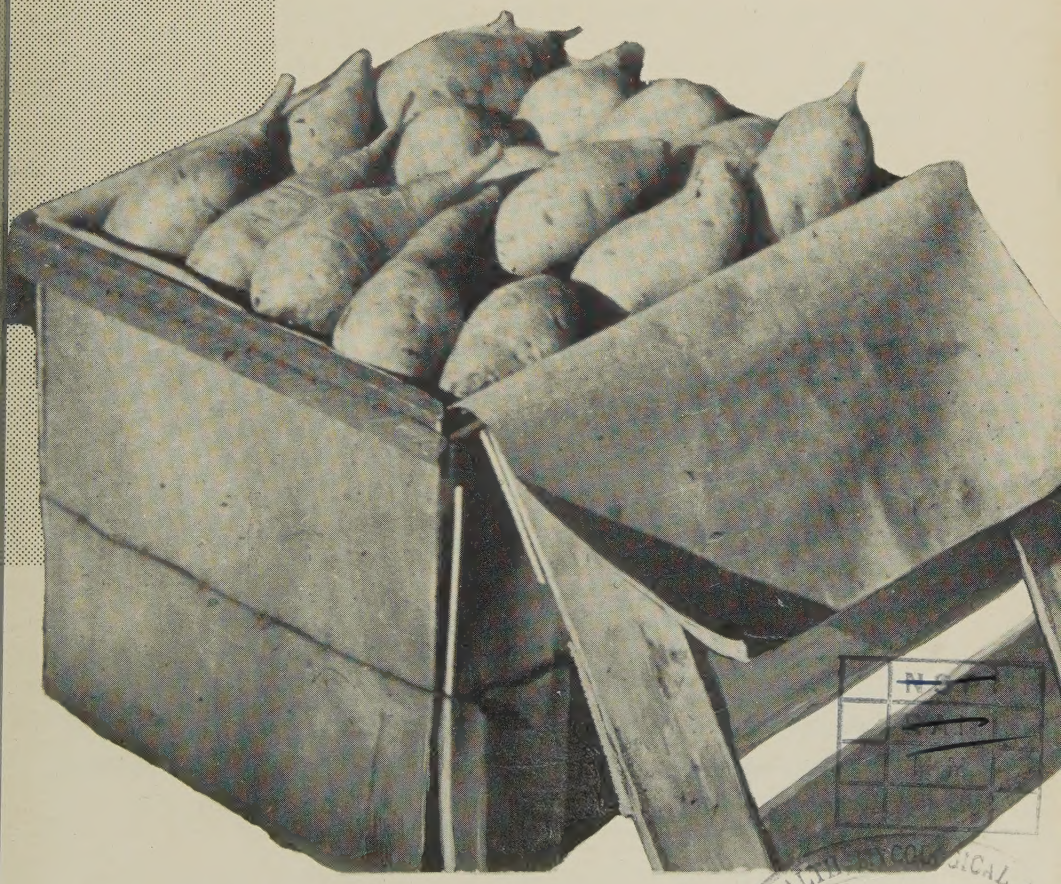
Farmers Bulletin No. 1442

Storage of SWEETPOTATOES



4 MAY 1959

U. S. DEPARTMENT OF AGRICULTURE

Storing sound, disease-free sweetpotatoes in suitable storage places makes them available throughout the year.

Observe the following points in storing sweetpotatoes:

(1) Clean and disinfect the storage house.

(2) Harvest before the crop is injured by cold.

(3) Dig and handle carefully to avoid wounding.

(4) Select sound, disease-free roots for storage.

(5) Store in properly stacked containers.

(6) Cure immediately after harvest, preferably at 85° F. and a relative humidity of over 90 percent for about 4 to 7 days.

(7) Then store at 55° to 60° F. and a relative humidity of 85 to 90 percent.

Contents

	Page
Need for sweetpotato storage	1
Requirements for sweetpotato storage	1
Disinfection of the storage house	1
Harvesting in time to avoid cold injury	2
Proper digging and handling	3
Selection of sound, disease-free roots	5
Filling the storage house	5
Curing	7
Care during storage	11
Curing and storing small lots for home use	12
Preparation for market	13
Construction of storage houses	16
General requirements	16
Insulation	19
Ventilators	26
Heating requirements	30
Heating equipment	31
Suggested designs for new storage houses	35
Converting existing buildings	39
Type of building to select	39
Foundations and floors	39
Walls, ceilings, windows, and doors	40
Structures for storing small quantities of sweetpotatoes	40
Storage in pits and cellars	42

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STORAGE OF SWEETPOTATOES

By

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NEED FOR SWEETPOTATO STORAGE

Storage of sweetpotatoes, which have an important place in the human diet, benefits both the producer and the consumer, since it makes sweetpotatoes available throughout the year. Sweetpotato production in the United States ranged from about 29 to 68 million bushels during the period 1944 to 1953. Not all of this crop is marketed, but over half of that which is sold moves to market between November and June. Most of this must be stored for some time. Loss during storage, much of which can be prevented, is tremendous. Losses of 20 percent are not unusual and those of 50 percent or even more are by no means rare. It is obvious, therefore, that there is much room for improvement in sweetpotato storage.

REQUIREMENTS FOR SWEETPOTATO STORAGE

Seven important points must be observed if the most satisfactory results are to be obtained in the storing of sweetpotatoes: (1) The storage house must be clean and sanitary; (2) the crop must be harvested in time to avoid low-temperature injury; (3) care must be taken to avoid cutting, bruising, or other injuries of the sweetpotatoes during digging, picking up, grading, placing in containers, and moving to the storage house; (4) injured roots and those showing disease must be kept out of storage; (5) sweetpotatoes should be stored in properly stacked containers; (6) the sweetpotatoes must be thoroughly cured immediately after being put into the house; and (7) the proper storage conditions must be maintained after curing.

Disinfection of the Storage House

Before sweetpotatoes are placed in the storage house all old or decayed sweetpotatoes or other debris should be cleared out and the floor should be swept clean. Crates and false floors should be cleaned also and repaired if necessary. Then the house should be disinfected by one of several methods, any one of which will be satisfactory if properly carried out.

The most effective method is to fumigate the house with formaldehyde gas.

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[1] Earlier editions of this bulletin were written by H. C. Thompson, V. R. Boswell, and J. H. Beattie.

Formaldehyde, which is an irritating and poisonous substance, must not be breathed or allowed to get into the eyes. It is thus necessary to get out of the house quickly after the gas is released.

When formaldehyde is to be used, the following directions should be followed.

Each 1,000 cubic feet of space to be fumigated requires 3 pints of commercial formalin (a 40-percent solution of formaldehyde in water) and 23 ounces of potassium permanganate. As potassium permanganate loses its strength when exposed to the air, it should be kept tightly covered when stored. The required amount of formaldehyde should be placed in deep containers such as lard cans, garbage cans, open-end oil drums, or large crocks. The container should be of 5-gallon capacity or larger to keep the material from running over. The formaldehyde should not fill the container over one-tenth full, as it will boil up to several times its original volume upon addition of the permanganate.

For a large house several containers should be used. The required amount of permanganate for each jar is measured beforehand. All doors, windows, and ventilators should be tightly closed except one convenient exit door. Speed in handling is essential for safety.

Beginning with the container farthest from the door, pour the permanganate crystals quickly into the formaldehyde and proceed rapidly to the next container. After finishing with the container nearest the door, leave the house quickly and close the door. Because the gas generated is very irritating to the eyes, the use of goggles and gloves may be desirable. Keep the house closed at least 24 hours; then open and ventilate thoroughly for at least 2 weeks.

In place of the 23 ounces of potassium permanganate, 36 ounces of fresh bleaching powder (chlorinated lime) can be used. Bleaching powder is commonly retailed in 12-ounce cans; the contents of one of these cans can be used for each pint of formaldehyde.

If bleaching powder is used, care should be taken not to inhale the chlorine fumes given off as they are poisonous and very irritating.

Used crates, baskets, or grading tables that are to be used again for sweetpotatoes can be fumigated by keeping them in the house during the fumigation.

Remember, *Don't* fumigate the storage house with sweetpotatoes in it.

Another method is to spray the entire interior of the house with a solution of copper sulfate (bluestone) made in the proportion of 2 pounds of copper sulfate to 50 gallons of water. All bins and other containers previously used should be treated also. When weevils are present, recommendations of local county and State agricultural workers for control in sweetpotato storages should be followed.

Harvesting in Time to Avoid Cold Injury

Sweetpotatoes are very sensitive to low temperature and suffer injury at temperatures below 50° F., especially those below 40°. They will not withstand freezing for even a short time. This harmful effect of chilling has an important bearing upon the proper harvesting time. Many growers delay digging until the first light frost occurs, when the leaves of the plants may be damaged or killed in parts of the field. The belief is general that no damage to the roots will result unless the cold is severe enough to kill the stems of the plants. If the

roots are dug promptly after a light frost, this may be true; but if they are allowed to remain in the ground several days it is likely they will be damaged. Experiments by the Alabama Agricultural Experiment Station show that as many as 75 percent of the sweetpotatoes may be lost in storage when they are harvested several days after a frost.

Probably the best time to harvest for storage is after the leaves show a slight yellowing, indicating that growth is slowing up, and before or very soon after the first light frost. The earliest planted fields generally should be harvested first. The digging should be done if possible when the soil is dry and the temperature fairly high. Much less heat is required in curing if sweetpotatoes are harvested and cured when the weather is still fairly warm.

Proper Digging and Handling

The sweetpotato root is covered by a thin, delicate skin that is very easily broken. Striking the roots with harvesting implements or throwing them from row to row or into containers injures this skin. The sweetpotatoes may be cut or bruised if they are placed in crates or other containers that have sharp edges or rough places on the inside or if the packages are roughly hauled or handled.

If a sweetpotato is cut or bruised during harvesting or handling, a heavy, sticky, milky juice exudes from the injured cells. This juice dries in a few hours and may appear to have closed the wound but actually several days are required for the growth of new cells that protect the interior cells from infection. The dried juice on the surface of a wound on a sweetpotato is in itself no appreciable protection against rotting; such a root is not safe from storage diseases.

Various methods are used for digging sweetpotatoes. In general, large plows with 14-inch or larger shares do less damage than small ones. These should be set deep enough to get under the sweetpotatoes and not cut them.

Probably the best tool is a 16- to 18-inch tractor-drawn turning plow with a vine-cutting colter in front of it. The shin of the plow should be lined up with the off edge of the hills of sweetpotatoes and the share should cut under the center of the hills. Good results have also been obtained with large tractor-drawn middlebusters set deep. Horse-drawn middlebusters usually cut many sweetpotatoes because they are not set deep enough. When suitable tractor power is not available, a two-horse turning plow is probably the best tool. With such a plow good digging can be done by barring off one edge of the ridge and then uprooting the row on another trip in the same direction. Some growers harvest their crop with a mechanical Irish potato digger with all shakers removed and the chain carrying an appreciable amount of dirt. This digger may skin more of the roots than the large turning plow but this method probably leaves fewer sweetpotatoes in the ground.

One of the best ways to cut the vines is to use an 8-inch shielded rolling colter set shallow. Larger colters go too deep and cut many sweetpotatoes. The shield prevents the colter from going too deep and also forces the vines down against the soil where they will be cut cleanly. On a turning plow the colter is lined up with the plow landside. If used with a middlebuster, the colter is set about 6 inches off center (fig. 1) so that a row of sweetpotatoes will be turned over. The standard large rolling colters without shields, usually sold

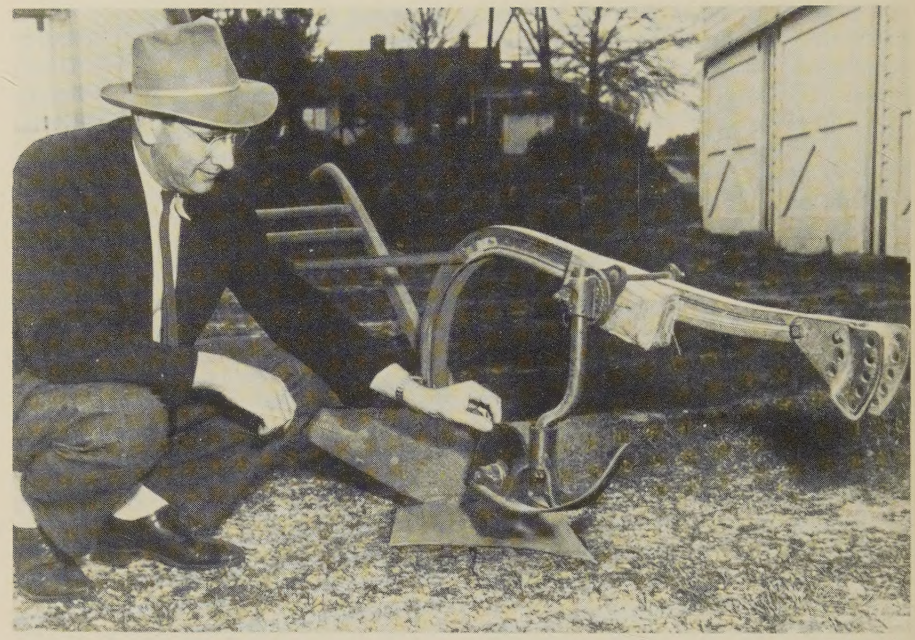

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Figure 1.—A two-horse middlebuster for digging sweetpotatoes, equipped with an 8-inch shielded rolling colter for cutting vines. Note that the colter is offset about 6 inches; also note the large point. This tool is satisfactory for digging when pulled by a tractor so that the plow can be set deep. A turning plow can be used with a similar colter lined up with the landside.

for land breaking, are not entirely satisfactory as often they do not do a good job of cutting the vines and are apt to cut the sweetpotatoes. Where sweetpotatoes are planted in checkrows a sled with knives attached (fig. 2) can be used to cut the vines one way and a colter on the plow to cut them the other way.

After the roots are plowed out, those that remain covered should be scratched out by hand. Gloves should be worn to prevent damage to the sweetpotatoes by fingernails. The sweetpotatoes should be picked up directly into the containers in which they are to be stored so that further handling will not be necessary. If much soil adheres to the sweetpotatoes, they should be exposed for an hour or two to dry before they are placed in containers except during hot weather when they should not be left exposed for more than a few minutes because of danger of sunscald. During warm weather when the sun is shining brightly the crates of sweetpotatoes should be covered with vines until they are hauled out of the field.

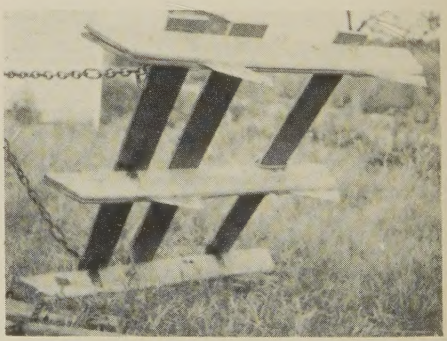

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Figure 2.—A sled with knives attached, used to cut vines one way when sweetpotatoes are planted in a checkrow system.

Sweetpotatoes should never be thrown from one row to another, thrown into "heap rows," thrown loose into a wagon or truck bed, or put into bags for hauling out of the field or for storing. All of these practices bruise and skin the sweetpotatoes, making them more likely to rot. If it will facilitate the work, one person or group may pick up the sweetpotatoes in 2 to 4 rows and place them carefully in piles and then another person or group may pick them up in crates or baskets (fig. 3). In most cases sweetpotatoes should be graded in the field in order to reduce bruising and the cost of later handling. A good plan is to go over the rows and pick up the sound marketable roots in one crate or basket and then to gather the roots of other grades in other containers.

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Figure 3.—Picking up sweetpotatoes and putting them in baskets.

Selection of Sound, Disease-Free Roots

Certain diseases of sweetpotatoes cannot be controlled by storage-house management. These diseases, as well as many that can be so controlled, occur first in the field, from which they may be carried to the storage house. In order to successfully store sweetpotatoes it is necessary to control diseases in the field. Complete freedom from any trace of disease in the field can hardly be expected; therefore the roots should be looked over carefully as they are picked up, and all those that show disease should be kept out of the storage or market containers. This is especially important with sweetpotatoes that are to be stored or held for any appreciable length of time.

Black rot is one of the most serious diseases of sweetpotatoes, but it can be controlled completely in the field by following 5 simple rules. It is important that each of these be followed because omitting one nullifies much of the value of the others. Briefly they are as follows:

(1) Bed in ground that has not been in sweetpotatoes for at least 4 years previously.

(2) Sort the stock very carefully at the time of bedding by examining every root and discarding all that show any sign of rot.

(3) Treat the sound sweetpotatoes for bedding by an approved method.

(4) Plant vine or bed cuttings or draws from disease-free seed stock.

(5) Plant on ground that has not been in sweetpotatoes for 3 or 4 years.

Filling the Storage House

Storage in crates or baskets is recommended. Generally the same container is used for both storing and marketing. A few containers will be lost, but if care is taken to prevent their getting broken or weather-beaten they can generally be used once for storage and once for marketing.

Unless the storage house has a

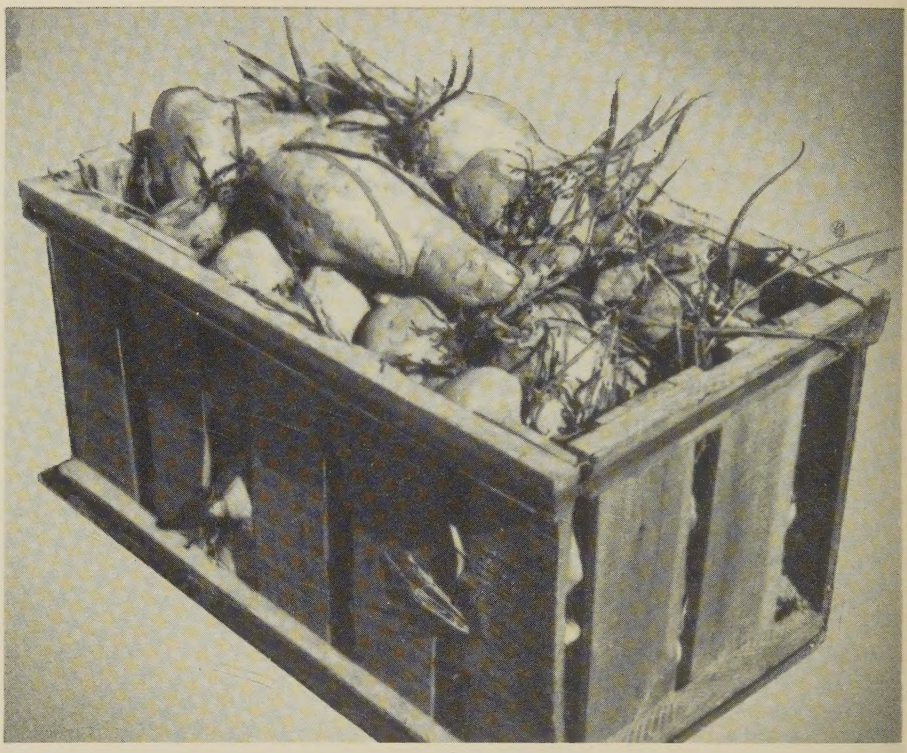

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Figure 4.—Crate of sweetpotatoes from the top of a 13-foot stack, showing excessive sprouting due to high temperatures under high humidity conditions.

fan or blower for circulating the air, stacking containers higher than 8 to 10 feet is not recommended; if the temperature of the bottom layer of higher stacks is right, that of the top will be too high; excessive sprouting (fig. 4) and consequent pithiness of the sweetpotatoes will result. Stacking too high may also result in buckling or breakage of the lower crates or baskets, especially under high-humidity conditions; however, it is sometimes necessary to store higher than 10 feet (fig. 5) because of shortage of space. In such cases it is best to dispose of the upper layers first. The containers should be stacked on a slatted floor above the earth floor.

Bin storage is not recommended because it involves extra handling and excessive bruising. If containers for storage are not available or if low-grade sweetpotatoes for which the expense of containers may not be justified are to be stored, the roots should be very carefully stored in bins. The bins should be filled one at a time starting at the back of each and working forward so that it will not be necessary to crawl over or step on any of the sweetpotatoes.

When there are several rooms in a storage house, one should be filled before another is started. Each room should be filled as rapidly as

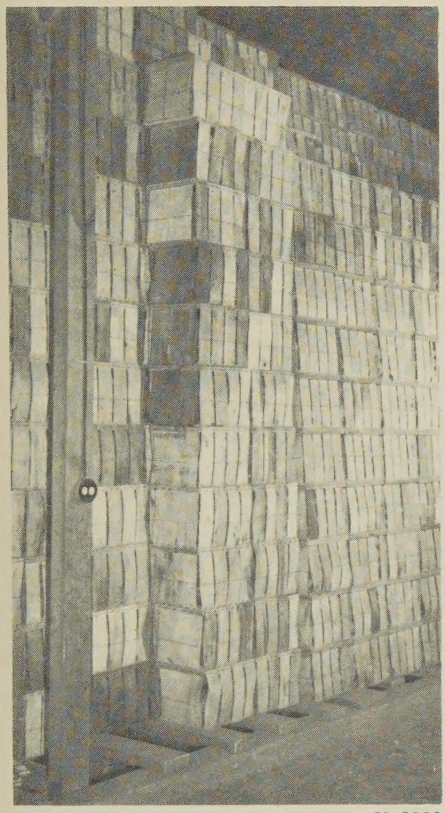

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Figure 5.—Method of stacking crates of sweetpotatoes on a slatted wooden floor raised above the earth floor.

possible—within 2 or 3 days if it can be arranged. In this way the curing will be uniform.

If filling a storage room takes a week or more, the first sweetpotatoes may be cured longer than desirable and the last ones only partly cured. It is therefore suggested that large storage houses be divided into several rooms each of which can be filled in 2 or 3 days. As the sweetpotatoes are sold, the rooms can be emptied one at a time and the heat cut off as they are emptied. It is easier to maintain proper temperature and humidity in a room which is full of sweetpotatoes than in one which is relatively empty. If the house is not divided into several rooms and it cannot readily be divided, it is preferable to place the lower layers of crates first throughout the house and then the upper layers, because the latter will be at a higher temperature during curing. If the suggested procedure is used, extreme care should be taken not to bruise the roots at the top of the first layers of crates; heavy boards should be placed on these for the workmen to walk on.

Curing

Even though the greatest possible care is used in harvesting and handling, there are of necessity at least two small wounds on almost every sweetpotato—on the ends, which are broken in harvesting. Any break in the skin affords a place for disease-producing organisms to get started.

A cut or broken place in sweetpotatoes will heal under proper conditions by the formation of new cells that are much like the cells of the skin in their ability to prevent infection. These new cells form a layer just beneath the wound; because of its corky nature this layer is commonly called wound cork. Workers in the United States Department of Agriculture have proved that this wound-cork layer greatly retards infection and to a large degree actually prevents it. This layer, which cannot be seen by the naked eye, is formed beneath the dried and hardened surface that soon develops over a wound, but only under certain favorable conditions as described in the next paragraph. The mere presence of a dried and hardened surface over a wound is no indication that it has been healed by a layer of wound cork beneath. The dry, hardened

surface of a wound may offer slight resistance to infection, but it is too little protection to afford safety.

Numerous investigations have been made to determine the exact conditions most favorable for this healing process. The most significant fact found is that wound-cork formation, or healing, proceeds most rapidly at approximately the temperature that has been recommended for properly curing sweetpotatoes. At 89° F. and a relative humidity of 92 percent, wound cork begins to form in 2 days and is well developed in 5 or 6 days. At lower or higher temperatures or at lower humidity it develops less rapidly. However, at a temperature of 85° and a relative humidity of about 85 percent, healing begins by the third day and proceeds rapidly. Even though the temperature is high enough, healing will not take place promptly if the air immediately surrounding the sweetpotato is as dry as 66 percent relative humidity.

Figure 6 shows the average results of 3 years' tests on losses during storage of sweetpotatoes not cured, cured at high humidity (82 percent), and cured at low humidity (50 percent). There was about 2½ times as much loss by decay after curing at low humidity as after curing at high humidity. As weight loss was also much higher, the total loss was about twice as much in the sweetpotatoes cured at low humidity as in those cured at high humidity.

Thus the sweetpotatoes should be cured as soon as possible after they are dug. A temperature of 85° F. and a relative humidity of over 90 percent are generally recommended for curing. It is desirable to hang a hygrometer (wet- and dry-bulb thermometer), such as that illustrated in figure 7 in each room for reading temperatures and determining the relative humidity during both curing and storage.

Sweetpotatoes can be exposed to the sun and wind for an hour or so immediately after digging, so that adhering soil will dry out and be more easily removed. No actual healing of cuts occurs on surfaces exposed to drying winds. If heal-

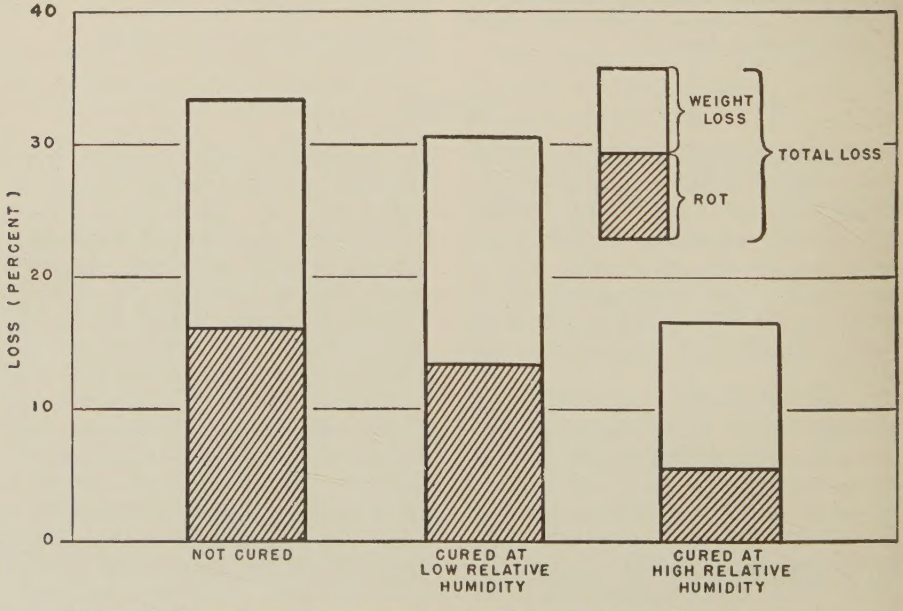

Figure 6.—Losses in sweetpotatoes not cured and cured at low and high humidities.

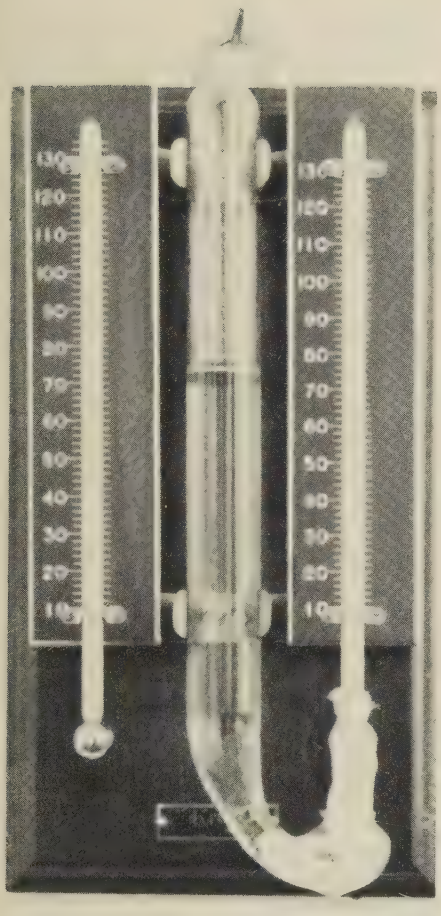

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Figure 7.—A stationary hygrometer (wet- and dry-bulb thermometer) for reading temperature and determining relative humidity.

ing is to begin promptly so as to build up protection against infection as soon as possible, the sweetpotatoes must be placed in storage at the prescribed temperature and relative humidity within a few hours after digging. Sweetpotatoes should not be left outside the storage house overnight if there is danger of low temperatures.

Very little ventilation is necessary or even desirable in most sweetpotato houses. In general, just enough ventilation should be used to prevent condensation. This not only helps maintain proper humidity but also reduces heating costs.

Maintaining a relative humidity of over 90 percent not only promotes healing but greatly reduces shrinkage. Even a fairly tight house may need no doors or ventilators open during either curing or storing. If there is evidence of free, condensed moisture in the house, some ventilation may be necessary. Opening the top ventilators is frequently all that is necessary; if this is not enough, however, both the top and the bottom ventilators should be opened. Large houses, especially if full of sweetpotatoes, require more ventilation than smaller ones.

When large, well-insulated rooms are filled with sweetpotatoes, care must be taken to prevent overheating at the top. Sweetpotatoes themselves give off considerable heat at high temperatures. If temperatures above 90° F. are reached in any part of the stack, the heat should be immediately turned off and the ventilators (and if necessary the doors also) opened to restore the proper temperature. When stacks of sweetpotatoes are higher than 8 to 10 feet, the temperature in the top layer should be checked daily during the curing period. In large rooms in which crates are stacked more than 8 to 10 feet high it may be necessary to use fans to circulate the air within the house and possibly to bring in outside air also. In such rooms there may be a considerable difference in temperature between eye level, where thermometers are usually hung, and the top of the stack. For example, in one large room of 6,000-bushel capacity, which was 14 feet high and contained crates of sweetpotatoes stacked 13 feet high, the temperature was 73° 6 feet from the floor, 90° at the top of the stack, and 64° at the bottom. The temperature at the top was above that

recommended for curing, that at the bottom was much too low.

In the extreme South artificial heat is not used for curing. For example, in the Lafayette-Opelousas district of southern Louisiana, natural heat only is used. Sweetpotatoes in that district are harvested for storage mostly from the latter part of September to the early part of November while the temperature is still rather warm. The usual practice is to store the sweetpotatoes in large quantities in large buildings of the warehouse type. Heat is used in these buildings only when there is danger of the temperature in them dropping below 50° F. As pointed out previously, sweetpotatoes themselves generate appreciable amounts of heat, especially when they are warm; therefore the temperature in these buildings is higher when they are full of sweetpotatoes than when they are empty. The usual practice is to keep the doors and ventilators open when the weather is warm and closed when it is cool. As the temperature inside these storage houses at harvesttime averages less than 85°, the period required for curing is longer than that recommended for curing at 85°. It is generally considered that a month is required for curing with natural heat.

The practice of "natural" curing is practical only where and when the temperature at harvest and for 3 to 4 weeks thereafter averages 70° or above day and night. Such a condition might exist when sweetpotatoes are harvested a month before the average first-frost date. Even in southern Louisiana sweetpotatoes harvested late or during unseasonal cold, wet periods have not always kept well. Under such conditions artificial curing might have been well worth while.

Many handlers of sweetpotatoes have claimed that a curing temperature of 85° F. is too high, that it causes excessive shrinkage, and that 75° is better. It has been shown that healing is slightly slower at 75° than at 85°. Some work by the United States Department of Agriculture showed that, although shrinkage during curing is slightly less at 75° than at 85°, during storage at 55° subsequent shrinkage is greater for the sweetpotatoes cured at 75°.

It is a good plan to have the temperature in a storage house about 70° F. when the sweetpotatoes are first brought in. When cold sweetpotatoes are brought into storage at curing temperatures (about 85°), especially if the humidity is high, considerable condensation of moisture on the roots occurs.

When large rooms that require a week or more to fill are used, a temperature of 70° to 75° is preferable to a higher temperature while the room is being filled. In this way curing of all the sweetpotatoes will start immediately and the first ones will not be overcured before the last ones brought in are properly cured. Although some operators use temperatures as low as 70° to 75° in curing the Little-Stem Jersey variety to avoid excessive sprouting, there are no conclusive experimental data to show that this is necessary. It is especially important to keep the humidity high in curing and storing varieties that have a tendency to shrivel.

The length of time required for proper curing cannot be stated as definitely as can the temperature and humidity requirements. The condition of the crop at harvest, the season of the year, the weather during the curing period, the temperature of curing, and the efficiency of the house and its operation, all determine how rapidly the curing process will proceed. In practice the length of the curing period generally ranges from 5 to 20 days, sometimes longer, depending largely on the ideas of the individual storage-house manager.

For sweetpotatoes harvested early in the South when the average outside temperature day and night is 70° F. or above no artificial curing is ordinarily used. As the season advances and the average outside temperatures drop to about 65°, the sweetpotatoes are cured for about 3 to 4 days at 85°. Later in the season just before the date of the first frost they are cured from 4 to 7 days at 85°. The reason for the difference between early- and late-harvested sweetpotatoes is that early in the season the outside temperature is high enough to produce the desired curing temperatures in the house and additional heat would result in excessive sprouting. However, when sweetpotatoes are harvested at or shortly before the average time of the first frost, temperatures are usually low enough so that there is little curing without artificial heat.

In general the following curing periods are suggested for sweetpotatoes harvested at about the time of the average date of the first frost:

Curing temperature (°F.):	*Days*
85°	4 to 7
80°	8 to 10
75°	15 to 20
70°	25 to 30

Curing too long results in excessive sprouting. It should be remembered that curing temperatures below 85° are generally not recommended. The suggested lengths of curing periods are given for cases in which it is impractical to cure at 85°.

The healing of wounds is but one of the several important changes that take place in the sweetpotato root during curing. A considerable loss in weight occurs, principally as a result of loss of water by evaporation but also to a small extent as a result of loss of solid substance through respiration. The combined weight losses from these two causes is commonly called shrinkage, although sweetpotatoes that have lost 5 to 10 percent of their original weight during curing do not appear shrunken or shriveled. A slight loss in volume accompanies the loss of weight, but if the curing has been done properly the roots will be sound and firm.

During curing sweetpotatoes lose water rather rapidly at first but the rate becomes relatively slow after about 10 days. Since most of the loss in weight is due to loss of water, one might suppose that the curing process causes the root to become more or less dried out. Many persons speak of well-cured sweetpotatoes as being well dried out; actually although the roots have lost 5 to 10 percent in weight, there is almost the same proportion of water and dry matter in them as before curing. Thus the flesh of properly cured sweetpotatoes when baked or otherwise cooked is apparently as moist as that of uncured ones. In fact the flesh of baked cured sweetpotatoes is apparently much more moist and juicy than that of similarly prepared uncured ones. Curing results in a decided improvement in the sweetness of the sweetpotato because of the rapid change of much of the starch to dextrin and sugars.

Care During Storage

After sweetpotatoes are cured, the temperature in the storage house should be brought down below 60°, but not lower than 55°, as rapidly as possible—preferably during the week or two after curing is completed, because continued high temperatures result in excessive sprouting.

For best results during the storage period the relative humidity of the air should be maintained at

about 85 to 90 percent. If it gets too damp in the storage house, the ventilators and possibly the doors should be opened, but care should be taken to prevent the temperature in the storage house from becoming too low. The desired temperature during storage generally can be obtained in warm weather by manipulating the ventilators. It is generally possible to cool a house by opening them during the night or during cool spells and by closing them during the day or in warm weather. Some operators leave the top ventilators open during mild weather and open the bottom ones only at night to cool the room.

Special care should be taken to prevent the temperature of any part of the storage from dropping below 55° F. During cold weather both the top and the bottom ventilators should be closed and if necessary the storage should be heated. Sweetpotatoes must be kept at 55° to 60° if satisfactory results are to be obtained.

A temperature of 40° F., although more than 10° above the freezing point of the sweetpotato, is definitely harmful. When sweetpotatoes are chilled, even though not frozen, there is a very marked increase in their susceptibility to infection by certain rot-producing organisms. If the temperature stays as low as 40° for 3 weeks or more, 40 to 90 percent of the sweetpotatoes may rot. One of the difficulties in connection with rotting as a result of chilling is that the damage does not appear at once but several weeks after the proper storage temperature of 55° to 60° has been restored.

A second effect of chilling is an internal discoloration and breakdown of the root that may occur even though it is not attacked by rots. This trouble also may not develop for several weeks after chilling unless the sweetpotatoes have been held at a temperature near the freezing point. An exposure of only 4 days at 40° F. has resulted in the development of this discoloration.

A third effect of chilling is reduction of the "seed" value of the roots; if the chilling is severe the sweetpotatoes may fail to produce any sprouts when bedded.

Formerly it was believed that sorting and removing the rotting sweetpotatoes would prevent the spread of rots, but experience and experimental studies have proved the opposite to be true. Sorting and handling cause some bruising of the roots and at the same time spread the rot organisms, so that the newly injured surfaces become infected.

Rats and mice injure roots and they doubtless cause an increase in rotting by carrying the rot organisms over the stored roots. Storage houses should be carefully constructed so as to make them rodent-proof. All ventilators should be screened with ¼-inch-mesh galvanized-wire cloth. Doors or other openings through which rats or mice might enter during ventilating periods should also be screened.

For extended storage in the South beyond April or May it is possible to substantially reduce sprouting and other losses until about August 1 by refrigerated storage at 60° F. This can be accomplished in installing air conditioning units in regular sweetpotato storages.

CURING AND STORING SMALL LOTS FOR HOME USE

There are several different ways of storing a few bushels of sweetpotatoes for home use. Suggested storage designs for small quantities are discussed on page 40.

Although curing sweetpotatoes

near a furnace has been recommended, generally this is not a good place as the low humidity there does not favor good curing unless roots are kept covered with a tarpaulin or are wrapped in newspaper or wet burlap sacks. After 2 weeks they should be placed in a part of the house which is relatively cool but in which the temperature does not drop below 55° F. A basement, an unheated pantry, a closet close to a heated room, or a second-floor room with a brick flue coming from a first-floor stove are possibilities.

Good results have been obtained by merely wrapping sweetpotatoes in newspaper and storing them in a closet in a building in which only enough heat was used to prevent the temperature from dropping below 55° F. Another recommendation is packing sweetpotatoes in sawdust or ground corncobs, holding them for 2 weeks at a temperature of 75° to 85°, and then placing them in a cool place where the temperature will not drop below 55°. If sawdust is used, care must be taken to see that it is very dry; otherwise, root growth will start.

Although storing in pits (banks) is not recommended, this method of storing may be used when there is no other place. (See p. 42.)

PREPARATION FOR MARKET

One reason why farmers often receive low prices for sweetpotatoes is that they have used improper methods of growing, handling, and marketing. Often the roots are badly bruised and cut in digging, are put in bags or other unsuitable containers without being graded, or are rushed to market when there is an oversupply. Careful grading, cleaning, and packing the product and putting it on the market when there is a good demand means better prices.

When sweetpotatoes are to be marketed they must be carefully graded. The market demands uniform medium-sized sweetpotatoes, free from bruises or decayed spots. In grading, those that are too large or too small, as well as those that are misshapen, cut, or bruised, should be used for making stock feed or for canning.

After being carefully graded, the sweetpotatoes should be put into clean, attractive packages. The wire-bound bushel crate, bushel hamper, or bushel basket are generally used. An attractive pack of well-graded sweetpotatoes will usually bring a better price than an ungraded one.

It is possible to ship sweetpotatoes to the market from the South all the year round. By bedding and planting early in the warmer sweetpotato districts, the early, or green, crop can be shipped immediately after harvesting without curing from early July through October or November. From November on until the next new crop is ready, shipments are made from cured stock. In the extreme South it is generally not advisable to hold for late digging and storage any part of the crop which was planted for early market, because these sweetpotatoes are not so well shaped as those from later plantings. If they are allowed to continue to grow too late, a rather high percentage of them will become Jumbos, which are too large for market.

The general practice is to wash (fig. 8) both the newly harvested and the cured sweetpotatoes before they are packaged for market. When black rot is present, washing seriously spreads the disease par-

M–2838

Figure 8.—Pouring sweetpotatoes from a crate into a washer.

ticularly in the freshly harvested crop; however, the sweetpotatoes are still washed because of market demands for an attractive product.

If black rot has not been eliminated in the field, the sweetpotatoes showing symptoms of black rot when dug should be disposed of promptly. Sweetpotatoes from lots that show no signs of black rot at harvest often develop serious amounts during storage or marketing.

Washing should not be more extensive than necessary to remove the soil. Care should be taken not to make fresh wounds such as broken ends because of the danger that soft rot organisms may infect them. A washing and grading line of common type consists of the following equipment:

(1) An overhead spray washer with underneath rollers.

(2) A roller-conveyor type of sorting table to permit removal of unsound sweetpotatoes.

(3) An underneath brush and overhead spray washer.

(4) A 10- or 12-foot section of a roller-belt conveyor for draining.

(5) A roller- or flat-belt conveyor for grading.

In some storage houses the marketable sweetpotatoes are picked from this conveyor and placed in shipping containers (fig. 9) and the unmarketable ones are dropped off at the end of the belt; in other houses the unmarketable grades are picked off and the marketable roots drop into containers at the end. Keep the number of places where the sweetpotatoes drop from one piece of equipment to another to a minimum and the drop as short as possible. All places where they drop should be cushioned with sponge rubber or similar material.

The sweetpotatoes in the top layer of the crate are all placed in one

M–2840

Figure 9.—Selecting marketable sweetpotatoes from a roller-belt conveyor and placing them in shipping containers.

M–2845

Figure 10.—Sweetpotatoes passing on a roller conveyor to a car door.

direction to present an attractive pack. They are weighed, lidded, and then loaded into a car (fig. 10) or truck. Many operators like to have their sweetpotatoes stored in the packing house for several hours to a day to permit them to dry off. Crates are stowed on their sides (fig. 11) so that they will not ride on the bulge.

All cull sweetpotatoes should be removed to a safe distance, dehydrated for stock feed, or buried to help prevent spread of disease. They should not be left near packing sheds or plant beds.

Sweetpotatoes shipped during the winter must be protected against cold. In no case should their temperature drop below 55° F. In cold weather cars should be shipped under Carriers' Protective Service so that the sweetpotatoes will be protected against cold.

Figure 11.—Method of loading crates of sweetpotatoes in a truck. Note that they are loaded on their sides so that they will not ride on the bulge.

CONSTRUCTION OF STORAGE HOUSES

General Requirements

A sweetpotato storage house, like most other farm buidings, is best located on a well-drained site. Placing the building so that trucks or wagons may be driven to the doors without difficulty, saves time and labor in handling. Locating the building on the opposite side of a hill or other windbreak from the prevailing wind will help reduce the amount of heat required for curing and storing the sweetpotatoes. Farm storage houses which are to be heated by electricity should be located close to the power pole so that proper voltage will be more certain. Sometimes sufficient space for sweetpotato plant beds can be left next to the storage house and the same heating facilities can be used for both, especially if hot water or steam is used for heating.

A tightly constructed building is important for uniform temperature and humidity, controlled ventilation, and heat savings. Doors should be insulated and should fit tightly. Often insulation board is applied to both sides of the door—the exterior side must then be covered with a weather-resistant material. In the colder parts of the sweetpotato-producing area two doors—one opening out and the other opening in—or a vestibule may be used. Weather stripping is generally advisable. All extra doors should be eliminated because they are expensive and waste heat. Windows are not needed except in the grading rooms.

Good construction and insulation are particularly essential in the colder parts of the sweetpotato-producing area. Even in the south-

ern temperature zone (p. 20), however, tight construction is important for control of ventilation and prevention of rapid temperature changes.

Continuous foundation walls simplify building construction and afford protection against vermin. They should extend at least 18 inches below the ground surface; a concrete shelf should extend at least 8 inches beyond the outer face of the wall to keep out rats. Footings should be made heavy enough to prevent cracking. Joints between concrete blocks, tile, or brick should be well filled. Stone, brick, solid concrete, concrete block, or tile is a suitable foundation material.

Earth floors are popular because of their low cost and the greater ease in maintaining high humidity. This type of floor is illustrated in figure 12. The earth should be leveled to make cleaning easier. With underfloor heat the bottoms of joists for the slatted floor supporting the containers should be at least 1 foot above the ground to permit free circulation of air.

Treat sills and other wood parts near the ground with a preservative to keep them from decaying.

A slatted floor made of 1 x 4's spaced ¾ inch apart is necessary to permit air circulation. It should be made in sections to allow easy removal for cleaning. The slats can be cleated together with 1 x 4's and can rest directly on the joists. In buildings with solid wood or concrete floors the slats should be attached to 2 x 4's if underfloor heating, such as that by electric heaters or steam or hot-water systems, is to be used. The 2 x 4's are supported by 2 x 10's or larger joists, which rest directly on the wood or concrete floor. This arrangement allows air to circulate across the heaters or pipes and upward through the sweetpotatoes. If underfloor heating is not to be used, the 2 x 4's supporting the slats are often laid

M–2846

Figure 12.—Earth floor with slatted floor above for supporting sweetpotato containers. The floor joists are on footings at least 1 foot high to permit free circulation of air. The slatted floor is in removable sections for ease in cleaning. Electric strip heaters are installed between the 2 floors: A, Reflector strip, B, heater.

directly on the ground. This arrangement is sometimes used when artificial heat is not needed or when the building is heated by stoves. All wood in contact with or close to the ground should be treated with preservative to prevent decay or termite attack.

Safe stacking heights for sweetpotatoes in containers in storage houses with typical floor-joist sizes, spacings, and spans are given in table 1. This table may be used as a guide in determining sizes of joists needed and the heights for stacking in houses already built.

Wall and ceiling materials must be of a type which will withstand moisture. Masonry walls built of cinder or concrete block or of tile and sometimes those built of brick or stone are relatively windtight and watertight and provide permanent construction at low upkeep cost. Asbestos-cement boards are not affected by moisture or decay, are fire- and vermin-resistant, do not require painting, and are reasonably strong when properly supported. Galvanized sheet steel is relatively low in first cost, is easy to apply, and has advantages similar to those of asbestos-cement boards. Aluminum sheets are also satisfactory as interior lining or exterior finish but should not be used in contact with earth. Moisture-proof plywood, laminated asphalt-felt board, and emulsified-asphalt-gypsum board are suitable materials when properly installed. All commercial materials should be installed in accordance with the recommendations of the manufacturers.

A wood interior lining has a reasonably long life if the walls and ceilings are properly insulated so that little condensation occurs. Protection from moisture can be obtained best by covering the wood with a vaporproof membrane and fastening it down tightly with closely spaced lath or other wood strips. The use of vaporproof membranes is discussed in the next section.

Logs make an excellent building if properly erected and kept tightly calked. Considerable labor is involved in this type of construction, which must be taken into account.

Selection of materials and type of construction will depend primarily on local availability of materials, cost of the building when erected, and need for a permanent or a temporary building. The additional expense involved in providing the necessary insulation must be considered.

TABLE 1.—*Safe stacking heights for sweetpotatoes in containers for various sizes, spacings, and spans of rough southern pine joists* [1]

Joist size	Distance between joists	Safe stacking height for indicated joist span [2]					
		4 ft.	6 ft.	8 ft.	10 ft.	12 ft.	14 ft.
	Inches	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*
2×6 inch	12	15	7	4	2	------	------
	16	11	5	3	2	------	------
	24	8	3	2	------	------	------
	30	6	2	------	------	------	------
2×8 inch	12	------	13	7	4	3	2
	16	15	10	5	3	2	------
	24	10	6	3	2	------	------
	30	8	5	2	------	------	------
2×10 inch	12	------	------	11	7	5	3
	16	------	13	9	5	3	2
	24	13	9	5	3	2	------
	30	10	7	4	3	2	------

TABLE 1.—(Continued) *Safe stacking heights for sweetpotatoes in containers for various sizes, spacings, and spans of rough southern pine joists* [1]

Joist size	Distance between joists	Safe stacking height for indicated joist span [2]					
		4 ft.	6 ft.	8 ft.	10 ft.	12 ft.	14 ft.
	Inches	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*
2×12 inch	12	------	------	15	10	7	5
	16	------	15	11	7	5	3
	24	15	10	7	5	3	2
	30	12	8	6	4	2	2
3×6 inch	12	------	11	6	4	2	2
	16	------	8	4	3	2	------
	24	11	5	3	2	------	------
	30	9	4	2	------	------	------
3×8 inch	12	------	------	11	7	4	3
	16	------	14	8	5	3	2
	24	15	9	5	3	2	------
	30	12	7	4	2	------	------
3×10 inch	12	------	------	------	11	7	5
	16	------	------	13	8	5	4
	24	------	13	8	5	3	2
	30	15	10	6	4	3	2
3×12 inch	12	------	------	------	15	11	8
	16	------	------	------	11	8	6
	24	------	15	11	7	5	4
	30	------	12	9	6	4	3
4×6 inch	12	------	14	8	5	3	2
	16	------	11	6	4	2	2
	24	15	7	4	2	------	------
	30	12	5	3	2	------	------
4×8 inch	12	------	------	14	9	6	4
	16	------	------	11	7	4	3
	24	------	13	7	4	3	2
	30	------	10	5	3	2	1
4×10 inch	12	------	------	------	14	10	7
	16	------	------	------	11	7	5
	24	------	------	11	7	5	3
	30	------	13	9	5	4	3
4×12 inch	12	------	------	------	------	14	10
	16	------	------	------	15	11	8
	24	------	------	15	10	7	5
	30	------	------	12	8	5	4

[1] If joists are surfaced on four sides, select the size next larger than shown in the table for the desired stacking height.

[2] Values figured on the following basis: Weight supported by joists, 36 pounds per cubic foot; joists, rough, full-size; bending stress, 1,200 pounds per square inch; horizontal shear, 135 pounds per square inch. Maximum stacking height 16 feet.

Insulation

Heat is lost from a sweetpotato storage house in three ways: (1) By direct transmission and radiation through walls, ceilings, and floors; (2) by escape of heated air through cracks around windows, doors, and other places where the building is not joined together tightly; and (3) by escape of heated air through ventilators.

If the building is tightly constructed and ventilation is properly controlled, the only other way to reduce heat loss and conserve fuel is to properly insulate walls, ceilings, and sometimes floors. Some

building materials are better insulators per inch of thickness than others. Light, porous materials are the best insulators; wood is fair; and solid masonry is poor. Hollow-masonry units such as cinder blocks and clay tile are better than solid masonry, as the air spaces provide some insulation. In most instances structural building materials such as those just mentioned do not provide adequate insulation, and additional insulation is usually needed. The materials most generally used to provide insulation are the commercial types made in board, loose-fill, bat, or blanket form. There is little difference in the insulating value per inch of thickness between these various forms of commercial insulation. Reflective type insulation is becoming popular; it is lightweight and easy to install; when installed properly it provides as much insulation value as the other forms of commonly used commercial insulation. Peanut and cottonseed hulls have often been used as insulation. Sawdust also has been used, but it absorbs moisture readily and is difficult to keep dry.

The type of construction which may be selected will depend largely on local availability of various materials and their relative cost in place. The amount of additional insulation needed with the various construction types depends mainly on the outside temperatures. Much more insulation is needed in the colder northern zone than in the warm southern zone, especially when the cost of the fuel or electricity to be used for heating is high. The higher the fuel cost or electric-power rates the more heat must be conserved by the use of insulation; otherwise, the heating cost may be excessive. Regardless of the fuel used, however, a poorly insulated building will have wide variations in temperature.

In order to make specific recommendations regarding the type of construction, insulation, heating, and ventilation, the main sweetpotato-producing area has been divided into zones *A*, *B*, and *C* (fig. 13).

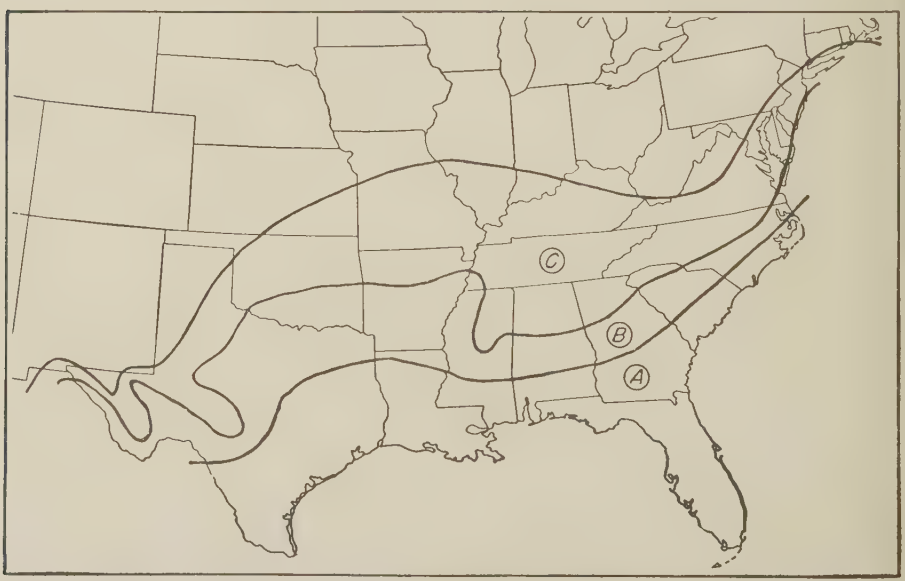

Figure 13.—Map showing division of the main sweetpotato-producing area into 3 temperature zones (*A*, *B*, and *C*). Approximate average daily minimum temperature for October: Zone *A*, 57° F.; zone *B*, 52°; zone *C*, 47°.

Several general types of wall construction are suggested (fig. 14) as a guide according to the temperature zone in which the building is to be located. They are divided into two general classes—class I and class II.

Class I construction includes walls Nos. 1, 2, 3, and 4 and class II includes walls Nos. 5, 6, 7, and 8. Class I construction is somewhat cheaper than class II. It is economical to use class I walls in localities where the selected fuel is relatively cheap. If the selected fuel is expensive, class II construction should be used. The price of fuel varies widely over the main sweetpotato producing area. This is particularly true of coal and natural gas, the price of which depends to a large extent upon the distance from the source. For example, natural gas may vary in price from 55 cents to $1.50 or more per thousand cubic feet. However, in most localities, wood, coal, fuel oil, and natural gas would be considered the lower cost fuels; bottled gas would be medium cost, but electricity high cost. Thus, class II construction is recommended in most cases when electric heat is to be used; it is not so essential for large storages in the warmer areas of zone *A*. Class II construction provides more uniform storage conditions in any area and economy in the use of any kind of fuel. Table 2 shows a comparison of commercial fuel costs based on assumed average prices and seasonal home heating efficiencies required to provide the same amount of heat.[2]

In deciding upon the construction and the kind of heat, however, the differences in initial cost of various heating systems and labor for operating them should also be considered.

The construction as shown in figure 14 or indicated in table 3 has sufficient insulation to keep condensation of moisture to a minimum except under extreme conditions. In all cases the roof or ceiling should be better insulated than the walls so that any condensation will occur first on the walls, where the water will not drip on the sweetpotatoes.

In the southern part of zone *A*, where little artificial heat is needed and where the temperature seldom falls below 40° F., the construction may be somewhat lighter than that generally recommended for zone *A*. This is particularly true in the construction of large storages holding several thousand bushels; in such storages the wall area and consequently the heat loss per bushel is much less than in small farm storages of similar construction. For example, in zone *A* a concrete-block or tile wall without interior lining should be adequate.

[2] Approximate Seasonal Efficiency, ASHAE Guide—1955, p. 438, American Society of Heating and Air-Conditioning Engineers.

TABLE 2.—*Comparison of Fuel Costs for Equivalent Heating*

Kind of heat or fuel	Assumed average cost	Percentage of highest cost
Electricity	2 cents per kw.-hr	100
Bottled gas	19 cents per gal	43
Natural gas	$1.25 per 1,000 cu. ft	29
No. 2 fuel oil	15½ cents per gal	28
Coal	$17 per ton	20

TABLE 3.—*Suggested wall construction*

Class and type of construction	Description	Zone	Insulation requirements for temperature zones shown in figure 14 [1]
Class I (low-cost heat):			
1	8-inch concrete block, 8-inch cinder block, or tile and furring strips.	A [2]	Dressed and matched lumber, shiny-surface roll roofing, lath strips; or ½-inch insulation board, 2 coats of hot asphalt or aluminum paint.
		B	¾-inch insulation board, 2 coats of hot asphalt or aluminum paint.
		C	1-inch insulation board, 2 coats of hot asphalt or aluminum paint.
2	8-inch concrete block or 8-inch cinder block.	A [2]	Granular-fill insulation in block, 2 coats of hot asphalt or aluminum paint on interior surface.
		B	
3	Wood siding, 15-pound felt, studs.	A [2]	Dressed and matched lumber, shiny-surface roll roofing, lath strips.
		B	¾-inch insulation board, 2 coats of hot asphalt or aluminum paint.
		C	1-inch insulation board, 2 coats of hot asphalt or aluminum paint.
4	Exterior of ¼-inch plywood, metal sheets, cement-asbestos, gypsum board, or similar material, studs.	A	¾-inch insulation board, 2 coats of hot asphalt or aluminum paint.
		B [2]	1-inch insulation board, 2 coats of hot asphalt or aluminum paint.
		C	1½-inch insulation board, 2 coats of hot asphalt or aluminum paint; or 1½-inch bat or blanket insulation between studs, shiny-surface roll roofing; or 2 reflective air spaces.[3]
Class II (high-cost heat):			
5	8-inch concrete block, 8-inch cinder block, or tile and furring strips.	A [2]	1-inch insulation board, 2 coats of hot asphalt or aluminum paint.
		B [2]	2-inch bat or blanket insulation between furring strips, shiny-surface roll roofing; or 3 reflective air spaces.
		C	3-inch bat or blanket insulation between 2 x 4 furring strips, shiny-surface roll roofing; or 4 reflective air spaces.
6	8-inch concrete block or 8-inch cinder block and furring strips.	A	Granular-fill insulation in block, dressed and matched lumber interior, shiny-surface roll roofing, lath; or granular-fill insulation in block, ½-inch insulation board, 2 coats of hot asphalt or aluminum paint.
		B [2]	Granular-fill insulation in block, 1-inch insulation board, 2 coats of hot asphalt or aluminum paint.

7	Wood siding, 15-pound felt, studs.	*A*	1-inch insulation board, 2 coats of hot asphalt or aluminum paint; or 1-inch insulation, shiny surface roll roofing; or 2 reflective air spaces.
		B	2-inch insulation, shiny-surface roll roofing; or 3 reflective air spaces.
		C[2]	3-inch insulation, shiny-surface roll roofing; or 4 reflective air spaces.
8	Exterior of ¼-inch plywood, metal sheets, cement-asbestos, gypsum board, or similar material, studs.	*A*	1½-inch insulation board, 2 coats of hot asphalt or aluminum paint; or 1½-inch insulation, shiny-surface roll roofing; or 2 reflective air spaces.
		B[2]	3-inch insulation, shiny-surface roll roofing; or 4 reflective air spaces.
		C[2]	3⅝-inch insulation, shiny-surface roll roofing; or 5 reflective air spaces.

[1] If no interior finish is to be applied, protect bat, blanket, or board or reflective insulation with 1- by 4-inch strips, 12 inches on center, to prevent damage which may result from striking the wall. Insulation requirements may be reduced in southern part of Zone A, especially for large storages.

[2] See fig. 14 for type for this zone.

[3] Reflective air spaces are formed with reflective insulation.

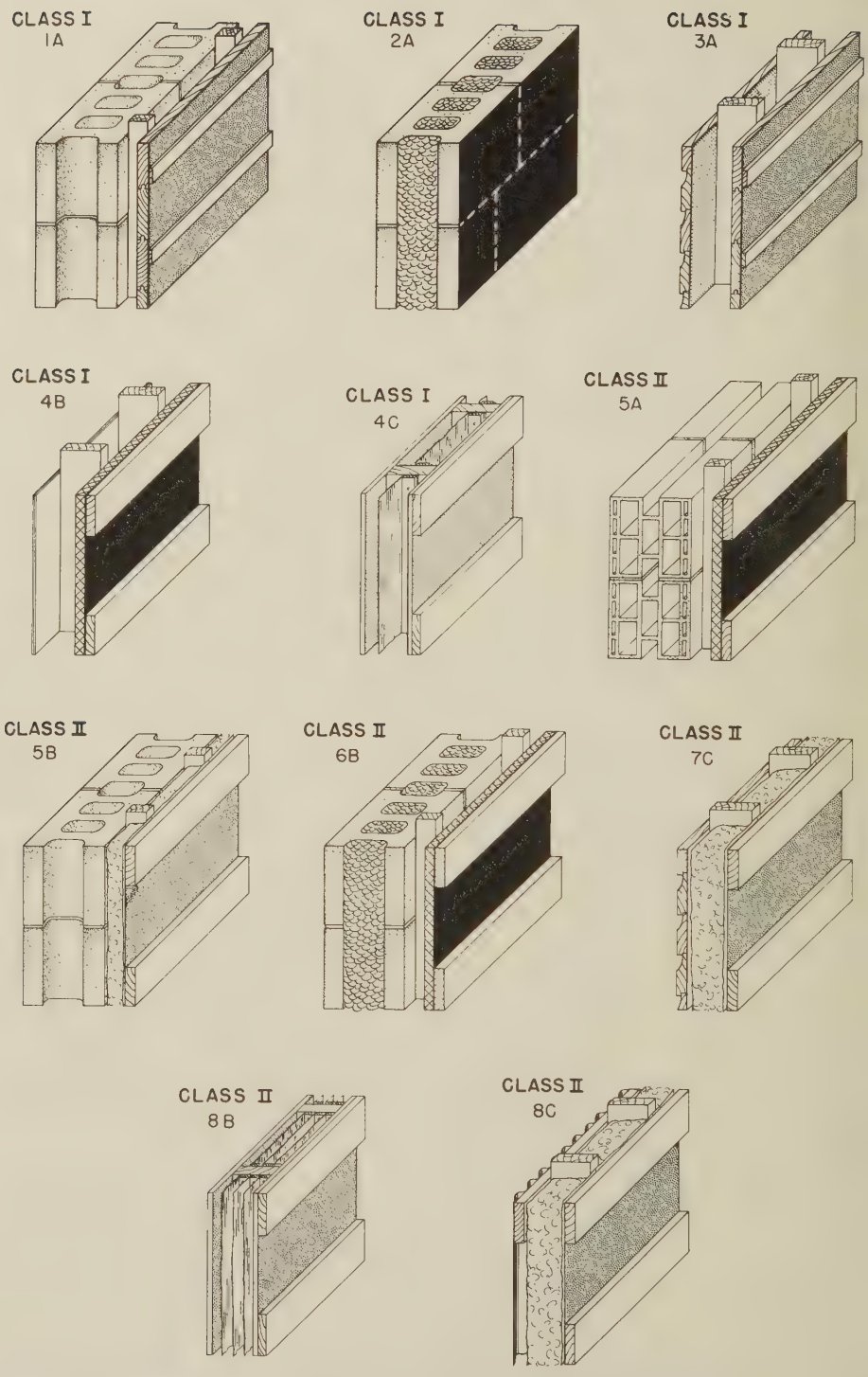

Figure 14.—Suggested types of wall for class I and class II constructions in zones A, B, and C. (For details see table 3.)

In the far northern part of zone *C* and in districts north of zone *C*, where the temperature often drops considerably below freezing, more insulation than generally recommended for zone *C* is desirable. It is especially needed on the ceiling in order to prevent excessive condensation and dripping of water on the sweetpotatoes.

There are several ways of insulating masonry walls. Concrete or cinder blocks or structural-clay tile, which can be placed so that air spaces, or cores, are vertical, can be filled with a pellet or granular type of insulation (expanded mica) as shown in figure 14. This type of insulation is easily applied and is generally less expensive than other types. It is not as effective, however, as some other types and its recommended use is limited as noted in table 3. The insulation is poured into the cores of the block or tile as each course is laid or after not more than two courses are laid. If more than two courses are laid before filling, the mortar from the joints which extend into the cores and forms ledges, tends to prevent complete filling.

If the granular type is not desired, the additional insulation needed is often most easily applied in board form over wood strips attached to the wall as illustrated. If a single thickness of insulation board is not sufficient, blanket or bat types may be installed between 2- by 2-inch or 2- by 4-inch furring strips. These furring strips are attached vertically to the walls or are built as separate stud walls. Strips 1 by 3 inches or 1 by 4 inches spaced about a foot apart should be nailed over the insulation so that holes will not be punched in it, or a moisture-resistant interior finish may be applied. Insulation in block form may be applied directly to the wall with mastics. This type of insulation must be covered with cement plaster to prevent damage to the insulation if the wall is struck.

Aluminum foil is most generally used for reflective insulation, although light gauge aluminum sheets are sometimes used; the bright surface reflects a high percentage of the heat which tends to pass by radiation through the air spaces in the wall, or other parts of the building. The aluminum foil insulation is made in several different forms: (1) In rolls of aluminum foil only; (2) in rolls of foil with kraft paper backing; (3) in rolls of foil on both sides with a layer of kraft paper between; or (4) in a multi-layer blanket folded in an accordion pleat or other fold. The kraft paper backing or center layer adds strength thus making it easier to install without tearing. The folded blanket type has several layers of foil or a combination of foil and kraft paper, the edges of which are fastened together to form flanges; it is easy to stretch this type across joist or stud spaces and staple the flanges to the framing members. To be most effective, layers of foil or foil and paper should be separated from ½ to ¾ inch when installed in walls; the air spaces bounded by these layers must also be tight. When used under average conditions encountered in sweetpotato storages, reflective insulation gives insulation values about equivalent to the following thicknesses of blanket, bat, or fill type—this is given in terms of number of air spaces rather than layers of reflective sheets:

Thickness of blanket, bat, or fill:	*Number of air spaces to give equivalent insulation*	
	In walls	*In ceilings*
1½ inches	2	3
2 inches	3	4
3 inches	4	5
4 inches	5	7

When installing aluminum foil insulation, it is essential that the flange fits tightly against the face of the stud or joist; otherwise air

leakage may be excessive and may reduce the effectiveness of the insulation. Wooden strips should be nailed over the flanges of the insulation and into the studs to make tight joints. Holes punched in the foil and dust collecting on the surface may reduce the effectiveness of this type of insulation. An interior finish will protect against both puncturing and dust; spaced slats will protect against most puncturing but not against dust.

Any material, when wet loses much of its insulating value. Therefore, insulation must be protected against moisture. To do this a tight seal or a vaporproof membrane must be provided on the inside of the house. Ordinary building felt or rosin-sized paper is not a vapor seal, and it should not be used for this purpose. Shiny-surface roll roofing or special membrane made of heavily asphalted building felt with a shiny surface is effective and necessary in a frame wall filled with insulation. The vapor seal should be fastened to the inside face of the studs or ceiling joists, with care not to punch holes in the seal. All joints over framing members should be made so that they will be sealed tightly when the interior finish is applied. Blanket and batt insulations are generally sold with a paper backing, but many of these backings are not effective vapor seals. To be assured of adequate and lasting protection a vaporproof membrane should be installed as for loose-filled insulation. Reflective type insulation is an effective vapor seal if the insulation is sealed tightly against framing members.

Board-form insulation having an asphalt coating is preferable to the uncoated type. The joints between the insulation panels should be filled with a waterproof compound and the entire surface should be mopped heavily with two coats of hot asphalt or should be painted with two coats of asphalt-base aluminum paint. A vaporproof membrane may be used in place of the hot-asphalt or aluminum-paint treatment. Spaced wood strips or a protective finish should then be added. Concrete- or cinder-block walls may be made vapor-resistant by painting the interior surface with a cement-water wash. When this wash is thoroughly dry, two coats of asphalt-base aluminum paint should be applied. Further details for installing commercial insulation can usually be found in directions given by the manufacturer.

The exterior of walls should be constructed or treated in some way to prevent entrance of moisture into the insulation from driving rain or snow. Two coats of cement-water paint should be thoroughly scrubbed into the pores of concrete- and cinder-block walls.

Frame walls with stud spaces filled with insulation and with a very tight exterior covering should be provided with small ventilation openings toward the outside at the top and bottom of the stud spaces. This permits the escape of any moisture which may accumulate in the insulation. Sometimes holes may be bored through the plates and sills, or openings may be made through the cornice.

Ventilators

Ventilation is most often required during warm weather in early fall and in the spring to avoid excessively high interior temperatures. This is especially true in the South. In zone *A*, where outside temperatures are high, the ventilators must be large and closely spaced, like those illustrated in figure 15 and 16.

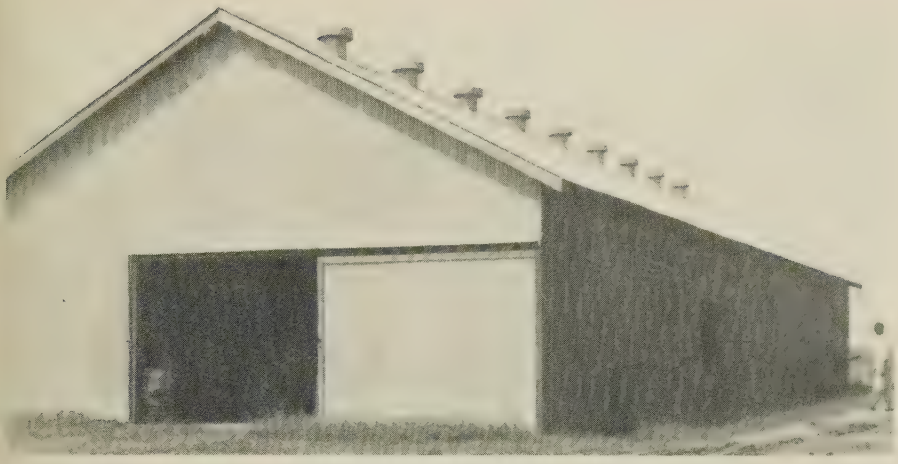

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Figure 15.—A typical sweetpotato storage house in southern Louisiana showing closely spaced commercial outtake ventilators.

Fewer openings of smaller size may be used in the northern part of zone *A* and in zones *B* and *C*. The sizes illustrated in the section on Suggested Designs for New Storage Houses are adequate for these sections. (See figs. 23–25.) In general the total area of intake ventilation should be approximately 1 percent of the floor area. More than this may be needed in most parts of zone *A*. The area of the outtake ventilators should approximate that of the intake ones. Commercial outtake ventilators such as illustrated in figure 15 may be used. Overhead outlets need to be insulated to prevent moisture from condensing and dripping on the sweetpotatoes. Dampers should be provided in the outtake ventilators so that the openings can be adjusted (fig. 17). Intake openings are usually placed at the bottom of the wall, thus permitting the incoming air to flow under the slatted floor (fig. 18). If regular entrance doors are used for ventilation, screens should be provided to keep out rats and other animals. Ventilators are not required in small houses such as the 60-bushel size illustrated in figure 27; the top half of the split door may be opened for ventilation and the bottom half left closed to keep out animals.

Natural ventilation can be depended upon to keep small storage houses reasonably near the desired temperatures. In large houses, however, it is impossible to cool the building as rapidly as needed or to prevent excessive temperature differences between the floor and the ceiling. Also, hand operation of the ventilators requires considerable labor. For these reasons the trend in storage houses for white potatoes [3] is toward the use of electrically driven fans or blowers, with thermostatic controls which start the blower when the inside temperature is too high or when there is too much difference between the temperatures at the floor and the ceiling. The controls are arranged to shut off the supply of outside air when it is either too cold or too warm. A duct system provides for uniform air movement through the

[3] For descriptions of systems used in white potato storage houses see Farmers' Bulletin 1986, Potato Storage.

N–20311

Figure 16.—Large, closely spaced intake ventilators in the wall of a typical southern Louisiana storage house. Note that the openings are covered with ¼-inch-mesh hardware cloth to prevent entrance of rats and other animals.

M 2848

Figure 17.—A common type of outtake damper.

M–2849

Figure 18.—A typical intake ventilator.

house. Although there has been little experience with such systems in sweetpotato storage recent studies have been made at the Coastal Plain Experiment Station, Tifton, Ga., using a fan mounted in the center of the ceiling of a 20′ x 20′ storage room and with outtake ventilators at floor level. Results indicated that forcing the air downward through the stacked crates of sweetpotatoes gave more uniform floor-to-ceiling temperatures than drawing the air upward. About 60 or more air changes per hour would be required to cool such a room properly during periods of warm weather.

Heating Requirements

Table 4 gives the approximate heating requirements for 500-, 4,000-, and 20,000-bushel storage houses. (See figs. 23–25.) These requirements are based on the amount of insulation suggested for the various zones and with ventilation restricted to the minimum necessary to maintain the humidity recommended (pp. 22, 23). It is also assumed that the houses are filled to capacity. The requirements shown can be used only as a rough guide in determining the size of the heating system needed, as differences in tightness of construction, exposure of the building, operation of ventilators and heating system, and type of heating can easily result in large variations from the values given.

In the southern part of zone *A* the heating requirements given may be reduced somewhat because the cold periods are short. In the northern part of zone *C* and in districts farther north the cold periods are longer; therefore to be safe the heating requirements given in table 4 should be increased about 25 percent. In any zone it is desirable to install heaters of some-

what larger capacity than the requirements indicate in order to be assured of adequate heat during periods of abnormally low temperatures. It should be noted that small storage houses require more heat in proportion to size than large ones, as the smaller buildings have more square feet of wall and ceiling area per bushel.

The heating requirements for earth-floor storage houses of the constructions recommended for the various zones and with capacities ranging from 500 to 20,000 bushels may be determined roughly by the following formula:

(1) Multiply total area of four walls and ceiling (square feet)—
  (*a*) By 5¼ for class I construction.
  (*b*) By 4 for class II construction.
(2) Divide the pounds of sweetpotatoes in storage by 6.
(3) Add results of line 1*a* or 1*b*, and line 2 to get the maximum number of British thermal units required per hour.

The capacity of a heating system may be rated approximately by the maximum amount of fuel which it will burn per hour. To get the heating capacity divide the number of British thermal units required (line 3)—

(*a*) By 7,800 for pounds of coal per hour.
(*b*) By 98,000 for gallons of fuel oil per hour.
(*c*) By 750 for cubic feet of natural gas per hour.
(*d*) By 75,000 for gallons of bottled gas per hour.
(*e*) By 3,400 for kilowatts.

For storage houses of less than 500-bushel capacity, it is advisable to increase the values given by the formula about one-fourth.

TABLE 4.—*Approximate capacity of heating systems for storage houses of indicated construction and storage capacity*

Class of construction and storage capacity	Heating capacity per hour [1]	Fuel-consuming capacity per hour of—				Electric load [1]
		Coal [1]	Fuel oil [1]	Natural gas [1]	Bottled gas [1]	
	British thermal units	*Pounds*	*Gallons*	*Cubic ft*	*Gallons*	*Kilowatts*
Class I:						
500-bushel	8, 600	1. 1	0. 1	11. 5	0. 1	
4,000-bushel	50, 000	6. 4	. 5	67	. 7	
20,000-bushel	224, 000	28. 8	2. 3	300	3. 0	
Class II:						
500-bushel	7, 500	1	. 1	10	. 1	2. 2
4,000-bushel	46, 000	6	. 5	61	. 6	13. 4
20,000-bushel	213, 000	27. 3	2. 2	284	2. 8	62. 5

[1] In mountainous districts in the northern part of zone *C*, and in districts farther north the quantity or capacity values should be increased 25 percent.

Heating Equipment

Coal-, oil-, or wood-burning stoves are commonly used for heating sweetpotato houses. It is very difficult, however, to maintain uniform temperatures with this type of heating unless thermostatic control is used. A sheet-metal jacket around the stove, elevated several inches above the floor and open at the top, helps prevent overheating nearby sweetpotatoes. To permit firing the stove, an opening should

be provided in the jacket or pulleys should be arranged for lifting the jacket. If the floors are wood, the stove should be set in a large shallow box of sand to reduce fire hazard. When the heater is undersized, close attention must be given to efficient firing and protection of the building, as a heater forced to its capacity is a fire hazard. The chimney should be carefully constructed. No part of a stove or piping should be installed closer than 3 feet to any unprotected wooden part of a building. An approved type of "flue jack" should be used wherever a pipe passes through a partition or a roof.

Electric heat has some advantages. The cost of the equipment is not high; the almost completely automatic operation reduces labor cost; the uniform temperatures and distribution of heat provided reduce storage losses; the capacity of the storage house is increased by the elimination of heating equipment and chimneys; and the danger of fire is less than with some other systems.

Where power rates are relatively high, heating by electricity may not be economical. In addition, because of the seasonal use of the electricity in curing and storing sweetpotatoes and the necessity of providing heavy-capacity service in some cases, demand charges are sometimes made by the power supplier. Information on rates and demand charges will help the storage operator to judge the economy of electric heating in each particular instance. Other factors such as initial cost of the heating system, maintenance cost, and labor for operation must be considered also.

Electric heat has been used successfully in both small and large storage houses. Records for well-built houses in the Southeastern States show that sweetpotatoes can be cured and stored with an electric-energy consumption of 1 to 2 kilowatt-hours per bushel. Small houses will consume more electricity per bushel than large ones. If the storage house is properly built and operated, the electricity used should certainly not exceed 4 kilowatt-hours per bushel for curing and storing several months.

In the colder districts electric heat is sometimes supplemented with stoves to provide adequate heat during short periods of very cold weather or during the curing period; thus an excessively large electric installation is avoided. The usual practice is to install electric heaters capable of providing at least 60 percent of the total heat required during such short periods.

If heaters require a total of not more than about 2,500 watts, 115-volt electric service may be used, but 230 volts give better service for installations over 2,500 watts. Generally, 2,500 watts should be adequate in most districts for houses of 300- to 500-bushel capacity, but the wattage required depends upon the amount of insulation in the building and the severity of the climate. It is desirable to have a 230-volt service for larger storage houses.

All electric installations should be in accord with the rules of the National Board of Fire Underwriters.

In storage houses having several rooms it is often desirable to equip one room with extra heaters for curing and storing late-harvested sweetpotatoes. Both the outside air temperatures and the sweetpotatoes are colder late in the season; therefore, more heat is required to maintain the proper temperature.

Electric heaters used in storage houses are usually of the strip type rated at 500, 750, or 1,000 watts. There are some indications that finned-type strip heaters provide

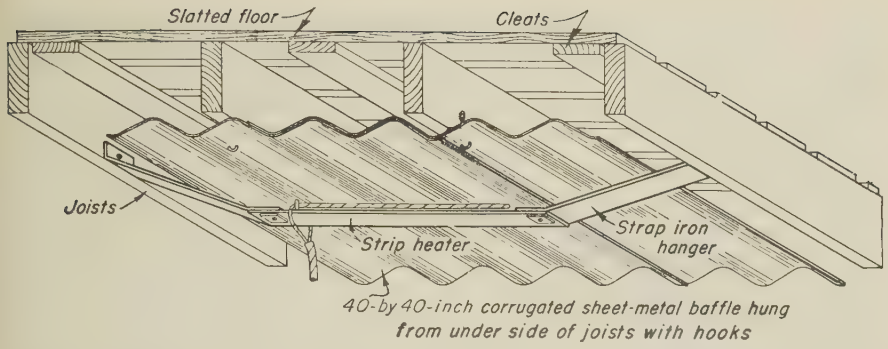


Figure 19.—Method of mounting an electric strip heater. The sheet-metal baffle prevents overheating of sweetpotatoes immediately above the heater. The size of baffle will vary with the size of heater.

slightly better heat distribution than the ordinary type. If the house has an earth floor, the heaters may be mounted several inches beneath the slatted-floor joists and supported as illustrated in figure 19. Heaters are generally mounted near the wall, opposite intake-ventilator openings. The additional heaters required to make up the total heating load are spaced uniformly under the rest of the floor (figs. 23 and 24). Baffles are placed directly above the heaters to prevent the potatoes over them from getting too hot and to protect the floors from fire.

At least one thermostat is needed in each room to control the temperature. It is usually mounted about halfway between the floor and the ceiling near the center of the room or a short distance from one wall. A typical installation is shown in figure 20.

When the total electric load exceeds the load rating of the thermostat, a relay must be used to control part or all of the heaters. In such an installation the thermostat controls the relay.

The hotbed type of thermostat has operated satisfactorily in many installations. It can be dismounted in the spring and used for controlling the temperature of electrically heated hotbeds if desired. A wafer-type thermostat (fig. 21) such as used in chick brooders is suitable in very small houses in which the electrical load is light. Special wafers designed for temperatures ranging from 50° to 85° F. provide

M–2850

Figure 20.—A typical thermostat installation.

BN–3900

Figure 21.—Wafer-type thermostat which can be used in very small houses. The control knob may be extended through the wall so that adjustments can be made from the outside.

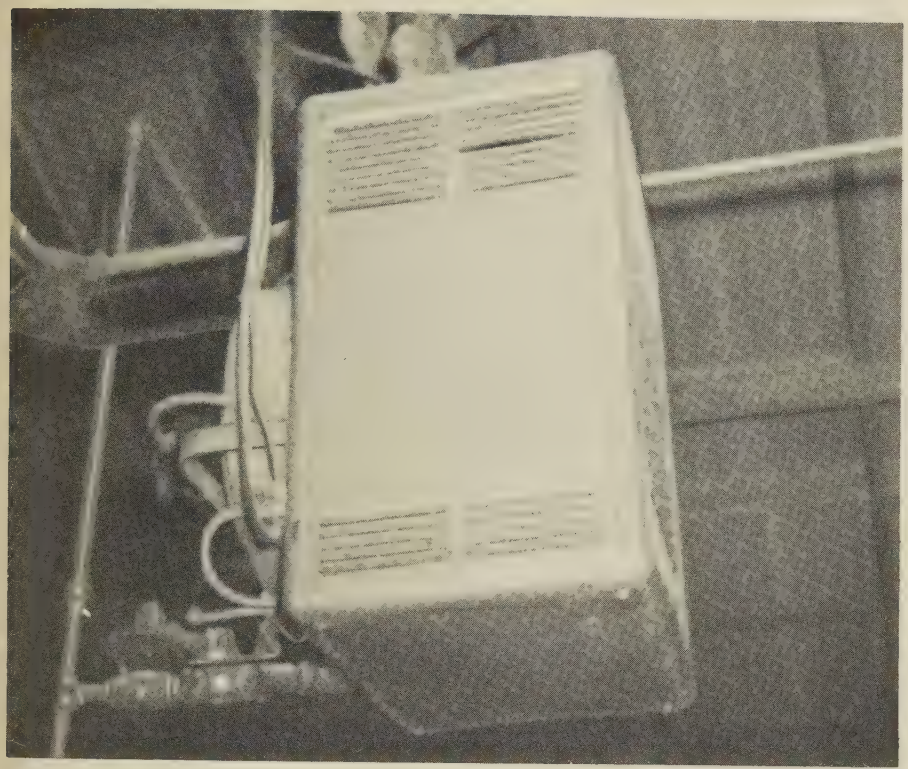
better temperature control. Even when so equipped, the wafer-type thermostat is sometimes difficult to adjust to the proper temperature. Also, if the wafer comes loose from the control rod that extends through the wall, it may be necessary to move some of the sweetpotatoes in order to replace it.

In addition to an entrance switch and lighting outlets, a few convenience outlets should be provided when the wiring is done.

If local electric-power rates are relatively high and the storage house is so large as to require excessively heavy electric installations, a steam or a hot-water system may sometimes be used more advantageously. When thermostatically controlled, oil, gas, or coal with stoker operation provides uniform and convenient heating somewhat comparable to electric heating. In small houses with earth floors the steam or hot-water pipes are run below the joists adjacent to outside walls and are supported by brackets attached to the walls or by straps attached to the joists. In larger houses the lines of pipe must be spaced at intervals under the floor in order to obtain uniform heat distribution. It is usually best to employ a heating contractor to determine the size of system needed and to make the proper installation.

Only one chimney is required with central-heating systems; thus in large houses the cost of masonry construction is less with central heating than with stove heating. In some cases a design for central heating provides a slight increase in storage capacity.

Where natural or bottled gas is available individual hand-controlled burners have been installed at a relatively low cost. However, this is not a recommended practice because of the danger of fire and explosions. Every gas burner should be equipped with a complete safety control. Thermostatically controlled units equipped with fans are also available. These are usually mounted near the ceiling as shown in figure 22. The fans may be operated without heat to assist air circulation within the house. Individual hand-controlled oil burners have also been used. Hand-controlled heaters do not provide uniform temperatures and are more of a fire hazard than central heating systems. For these reasons, thermostatic control is highly desirable.



BN–3901

Figure 22.—Typical gas-fired unit heater with built-in electric fan.

SUGGESTED DESIGNS FOR NEW STORAGE HOUSES

The perspective drawings and floor plans in figures 23 to 25 illustrate sweetpotato storage houses with capacities of 500, 4,000, and 20,000 bushels.[4] The working drawings for these houses show 18 inches as the minimum depth of outside foundations for zones *A* and *B*. It is recommended that this be increased to 36 inches or deeper for masonry buildings in the north-central part of zone *C*. The 18-inch depth in zones *A* and *B* is needed primarily as an aid in keeping out rodents, whereas in zone *C* the added depth is needed to place the footing at or below the frost line. If wood girders are substituted for continuous masonry floor support, the outside foundation walls must be made higher in order to provide clearance beneath the girders. Closely spaced piers may be used, as shown in figure 12; thus girders are eliminated. Assistance on special storage-construction problems can be obtained from the extension agricultural engineer, who is usually located at the State agricultural college.

[4] Working drawings for exchange plans shown in this bulletin are available from the extension services of many of the State agricultural colleges. If your State extension service cannot supply you with the drawings, information as to where they may be obtained may be had by writing the Agricultural Engineering Research Division, Agricultural Research Service, Beltsville, Md.

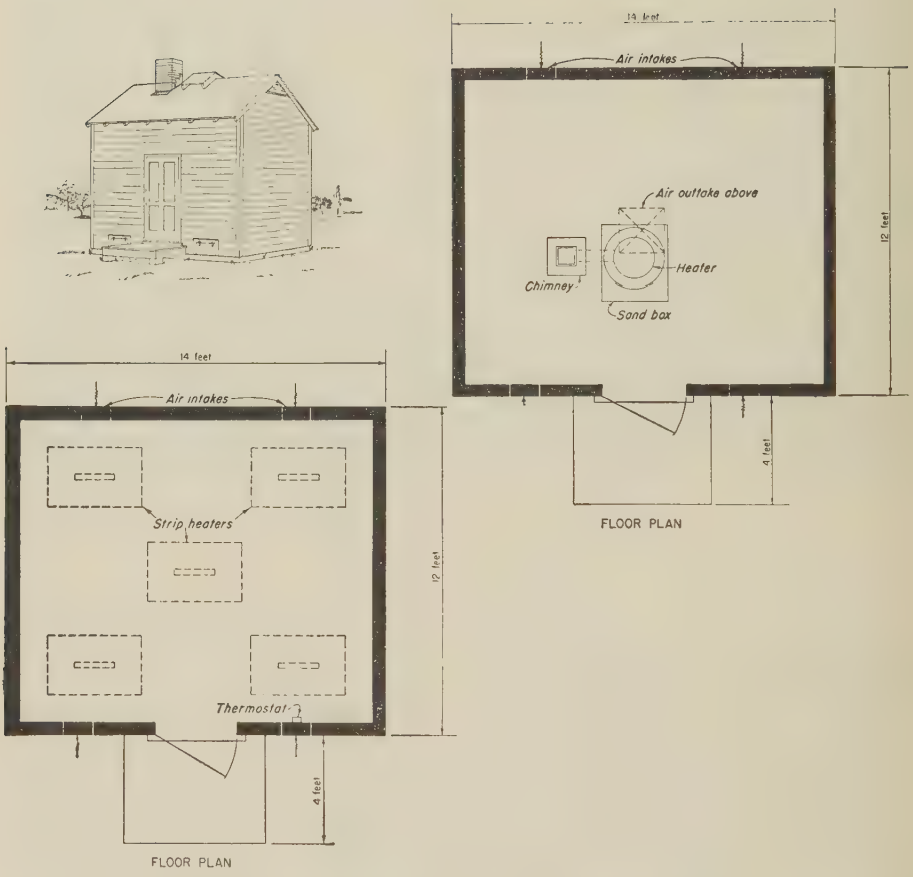


Figure 23.—A 500-bushel sweetpotato storage house. (Exchange Plan No. 5649.) Above: Plan for stove heat. Lower left: Floor plan for electric heat.

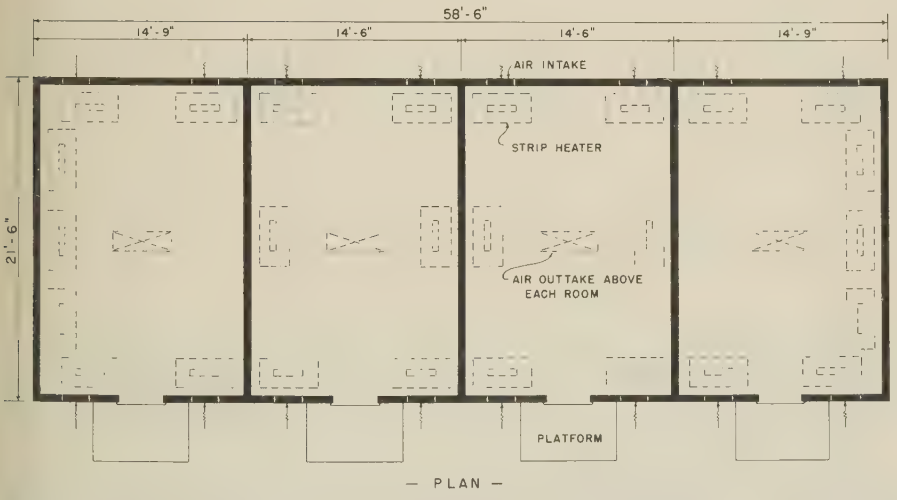


Figure 24.—A 4,000-bushel sweetpotato storage house. (Exchange Plan No. 5648.) Note recommended location of strip heaters for electric heating.

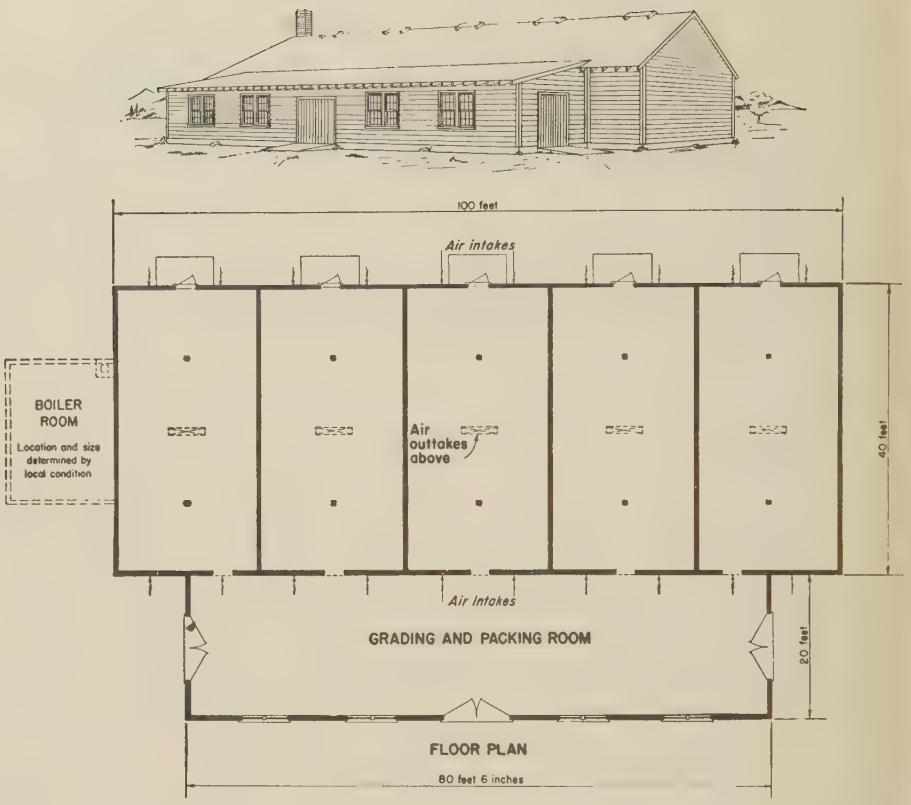


Figure 25.—A 20,000-bushel sweetpotato storage house. (Exchange Plan No. 5650.)

M–2851

Figure 26.—Typical sweetpotato storage house with grading room in one corner, lighted by windows. Note truck-entrance doors of grading room.

In large houses it is usually desirable to include a grading room. Double doorways at least 9 feet wide and 9½ feet high are sometimes provided for entrance by trucks. The floor of the grading room is only a few inches above grade. If preferred, the floor may be poured on a raised tamped earth fill so that it will be level with the floor of the storage room. In that case other arrangements must be made to permit outside air to enter beneath the slatted floor when ventilation of the storage room is needed. If desired, the floor of the grading room can be at car or truck floor level. Figure 26 illustrates a storage house with grading room in one corner and with truck-entrance doors.

Large houses may also allow for crate storage overhead by having the ceiling joists carried across the entire width of the storage at the plate level. A crate chute leading to the packing and grading room will increase the efficiency of overhead storage.

CONVERTING EXISTING BUILDINGS

Type of Building to Select

Storage of sweetpotatoes on farms eliminates long hauls which delay curing. Management of a building converted for sweetpotato storage can be handled by farm labor. Flue-heated tobacco barns are sometimes used. Tight grain bins and similar structures designed for heavy loads usually can be converted easily for the storage of sweetpotatoes. Large buildings can be used cooperatively by neighboring farmers.

Village buildings that are reasonably sound and tightly constructed can be converted economically, especially for larger, commercial storages. Single-story detached buildings are more easily converted than other types. Narrow, deep buildings attached to others are difficult to ventilate. Ceilings higher than 12 feet are not needed and waste heat. Except in warehouses designed for heavy loads, upper floors of multiple-story buildings are not desirable because of the difficulty of strengthening the floors. Basements can be used if they are not subject to flooding and can be ventilated.

The principles of construction, insulation, ventilation, and heating discussed for new buildings apply also to converting existing buildings. Therefore anyone who is planning to convert an existing building into a sweetpotato storage house should study the recommendations given in this bulletin for the construction of new storage houses.

Foundations and Floors

Foundations, walls, and floors of existing buildings should be examined to determine whether they are strong enough to carry heavy loads. Foundations that may need strengthening or require wider footings can sometimes be improved. Light girders may need stiffening by the addition of extra piers, and long joists may require supports, such as girders or solid walls. The height of sweetpotato stacks which rough southern yellow pine joists will carry is shown in table 1. Information on the relative strengths of various kinds of wood can be obtained from lumber dealers. An experienced builder

should be consulted if there is any doubt as to the best method of strengthening a building. In buildings supported by piers, the spaces between piers at the outside walls should be enclosed by masonry when the remodeled structure is to be a permanent storage house.

Walls, Ceilings, Windows, and Doors

The walls and ceiling of a proposed storage house should be insulated and effectively vapor-proofed according to the suggestions for new buildings. The insulation and interior finish should be installed with stud spaces blocked so that heat will not escape up the flues formed by the stud spaces. There will be less space to heat if the ceiling is applied to horizontal ties rather than to the under side of the rafters. Furthermore, thicker insulation must be placed in the ceiling than in the walls if dripping of condensed moisture on the sweetpotatoes is to be avoided. Defective joints of masonry walls should be raked out one-half inch deep and pointed up to make them windtight and watertight.

Where electric lights can be installed, windows are unnecessary and should be boarded up and insulated like the walls. Felt or other compressible material should be inserted between the frames to reduce infiltration. All openings between the frames and main walls at all windows and doors should be calked to keep out cold air.

STRUCTURES FOR STORING SMALL QUANTITIES OF SWEETPOTATOES

High-quality sweetpotatoes for home consumption or for seed stock can be economically cured and stored in small structures built especially for the purpose. The cost per bushel for the structure and for fuel or electric current is considerably more than that for larger houses. Electric heat is by far the most satisfactory type, especially as other methods of heating require too much space in such small structures.

The United States Department of Agriculture, in cooperation with the University of Georgia, has developed a 60-bushel storage house primarily intended to be built as an individual building. The design could be altered slightly, however, to make it suitable for construction within an existing building. The house is heated by means of two 250-watt, 115-volt strip heaters or a 60-foot length of soil-heating cable giving 400 watts of heating capacity. Operation of the heaters or cable is controlled by a hotbed-type thermostat, a wafer-type one such as is often used in chick brooders, or a bimetallic cartridge type. The house built at Athens, Ga., is shown in figure 27.

The Tennessee Valley Authority, in cooperation with the University of Tennessee at Knoxville, has obtained good results by curing and storing sweetpotatoes in insulated cabinets of 25-bushel capacity, which were installed in an unheated building. These cabinets were equipped with small floor and roof ventilators and a slat floor raised above the main floor. A 220-watt, 115-volt electric heater was mounted under the slat floor and was controlled by a wafer-type thermostat. Similar results have been obtained on experimental lots by the United States Department of Agriculture at Meridian, Miss. The cabinets at Meridian were con-

structed of 1-inch dressed and matched lumber and were lined with building paper.

Part of a farm building, such as a barn, could be walled off, ratproofed, and provided with a thermostat and small heating unit. The distance between the main floor and the slat floor should be the same as in a large house. The same safety provisions, such as installing baffles to prevent overheating and fire danger, should be followed. (See p. 33.) Many people already have thermostats and heaters for brooding baby chicks in the spring; these can be used for curing and storing small lots of sweetpotatoes during the fall and winter.

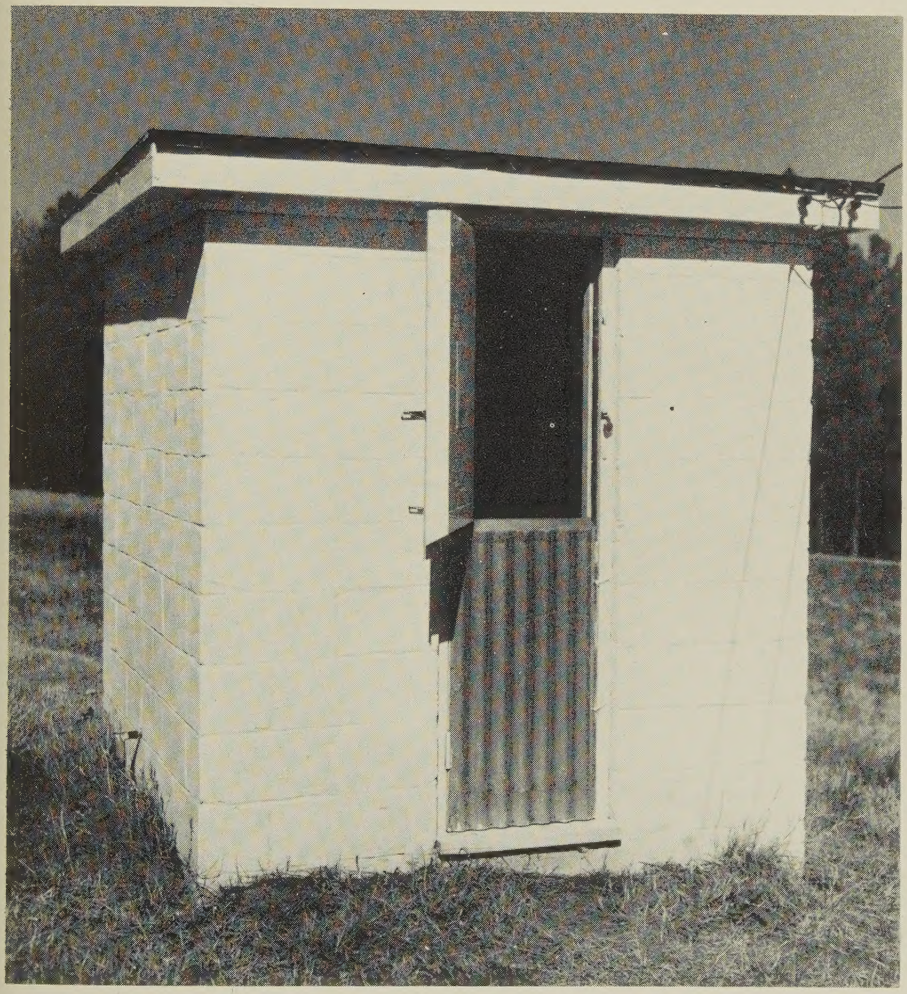


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Figure 27.—A 60-bushel electrically heated sweetpotato storage house. (Exchange Plan No. 5642.)

STORAGE IN PITS AND CELLARS

Storage in pits (banks) or outdoor unheated cellars is not recommended. Although many farmers generally have success in storing sweetpotatoes in banks, they lose most of their crop in some years. The main disadvantages in the pit method of storage are (1) the large proportion of loss due to decay; (2) the inferior quality of the sound sweetpotatoes as a result of lack of proper curing; (3) the loss on the market, because banked roots will keep for such a short period after being removed; (4) the inconvenience of getting the sweetpotatoes when needed, especially during cold or rainy weather; and (5) the danger of rats getting into the sweetpotatoes. Within a few years the saving in labor will offset the cost of providing some suitable storage structure. If a farmer raises too few sweetpotatoes to justify a storage structure such as one of the several types recommended in this bulletin, it may be possible for him to construct a suitable house in cooperation with some of his neighbors. If no other method is available, the loss by decay in pits can be materially reduced but not eliminated, by using the best methods of banking.

Storage pits should be located where the drainage is good. In making a pit a level bed of earth should be made a few inches above the ground level. Two small trenches should be dug across the bed at right angles to each other to provide for ventilation at the bottom. Over the trenches boards should be laid or inverted troughs should be placed; at the point where the trenches cross, a small box with open ends should be set to form a flue up through the pile of sweetpotatoes. If inverted troughs are used, the two small trenches are not necessary. The earth floor of the pit is covered with 4 or 5 inches of straw, hay, leaves, or pine needles, and the sweetpotatoes are placed in a conical pile around the upright flue.

A 3- or 4-inch covering of straw, hay, or similar material is put over the pile; on top of this are a layer of cornstalks and then a layer of soil. The soil covering should be only a few inches thick at first, but it should be increased to 8 to 12 inches as the weather gets cold. The ends of the trenches and flue should be kept open until it is necessary to close them with straw to keep out the frost. They should be screened to keep out rats and mice.

It is better to make several small pits rather than a single large one, because the entire contents should be removed when the pit is opened. A shelter over the pit is helpful.

Details regarding sweetpotato disease control, foundation and chimney construction, and termite protection can be obtained from the following U. S. Department of Agriculture publications:

Sweetpotato Diseases, Farmers' Bulletin 1059.
Preventing Black Rot Losses in Sweetpotatoes, Leaflet 280.
Foundations for Farm Buildings, Farmers' Bulletin 1869.
Fireplaces and Chimneys, Farmers' Bulletin 1889.

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